Contract #: N00014-12-C-0671

Awardee: Aurora Flight Sciences

9950 Wakeman Drive, Manassas, VA 20110

Amount Awarded: $13,409,980

Date Contract Signed: 9/28/2012

Statement of Work

Tactical Autonomous Aerial Logistics System (TALOS)

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1 Introduction

1.1 Background

The Autonomous Aerial Cargo Utility Systems (AACUS) Innovative Naval Prototype (INP) proposes to develop a modular open architecture sensor suite including supervisory control interfaces that can be rapidly and cost-effectively integrated and physically mounted on a number of different Vertical Take Off and Landing (VTOL) platforms. The primary purpose of AACUS is to enable unmanned and potentially optionally manned VTOL rapid response cargo delivery to widely separated small units in demanding and unpredictable conditions that pose unacceptable risks to both ground resupply personnel and aircrew. The wide applicability of the AACUS system for autonomous cargo capability across different VTOL platforms requires sufficient reliability to be entrusted with not just precision cargo delivery, but also in the long term, evacuating human casualties from remote sites.

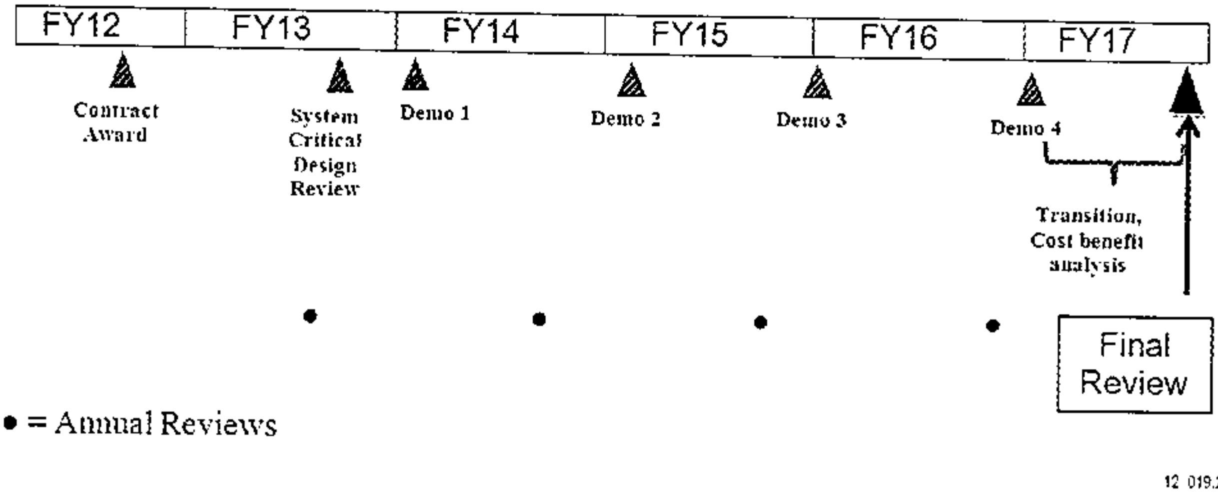
The primary focus of this effort is the development of threat and/or obstacle detection and avoidance sensor technologies, and autonomous landing site selection and descent-to-land capabilities that incorporate autonomous mission planning technologies in an open architecture framework that interface seamlessly with the air vehicle and Unmanned Aerial System (UAS) network and control infrastructures. In addition, a human operator with no special skills in operating a VTOL aircraft should be able to supervise and request services from this system. This BAA calls for multiple demonstrations of these technologies and framework on two separate airframes in progressively challenging scenarios as the AACUS system is matured through program execution.

The resulting sensor package and supervisory control interfaces from this effort are expected to be portable across different aircraft such that both legacy and new platforms can take advantage of AACUS. Due to increasing DoD concern for proprietary systems that hinder or prevent cost-effective upgrades and modifications, it is expected that as part of this effort, a Global Open Architecture Layer (GOAL) will be developed to allow portability (i.e., the software that allows a new or legacy platform the ability to "plug in" to the AACUS sensor suite will be open source.) However, it is expected that local vehicle control software will remain proprietary. The concept of modularity can also apply to components within systems or vehicles to enhance cross-system compatibility while simplifying field level maintenance and repair.

The AACUS system is envisioned to be a sensor suite mounted on VTOL platforms to accomplish the sense and avoid function. There are four major elements of the program: 1) a flight demonstration of the developed system on two air vehicles, 2) the sensor package, 3) the human supervisory control layer, and 4) the mission-centered global open architecture layer. There are three major interfaces envisioned for interaction with the system: (1) operations center ground control system, (2) field user, and (3) vehicle mounted system for ground communication.

1.2 Period of Performance

The total Period of Performance is expected to be 62 months ending in Sep 2017. The initial contract is expected to be 18 months, which includes the Base period also called "Task I". There will be four option periods that align with Tasks II, III, IV, and V. Down-select for these options is planned to occur after the base period. The envisioned milestone chart for the overall program is depicted in the figure below



2 Scope

This Statement of Work (SOW) establishes the overall goals, objectives, tasks and deliverables for the AACUS project. The Contractor shall provide the personnel, facilities, equipment, materials, tools, and effort necessary to successfully design, develop, integrate, test, and deliver the AACUS program. The AACUS program includes four major elements: 1) a flight demonstration of the developed system on two air vehicles, 2) the sensor package, 3) the human supervisory control layer, and 4) the mission-centered global open architecture layer. It is expected that capabilities will be enhanced as the program progresses and demonstration scenarios become more challenging. The contractor should seek out enhancements to the system and plan for their integration over the course of the program. The project is divided into five (5) tasks. The five tasks are described below.

Task I: 18 Months Base Option	Develop sensor package and supervisory control system. Integrate the AACUS system hardware and software with the initial demonstration platform. Demonstrate the AACUS system capabilities on a single representative platform for a representative cargo mission with a notional user in expected and unchanging conditions.
Task II: 11 Months Option 1	Adapt sensor package and supervisory control system with integrated mission-centered GOAL for second distinct demonstration platform. Integrate the AACUS system hardware and software with the second demonstration platform. Demonstrate the adapted AACUS system capabilities on the second representative platform for a representative cargo mission with a notional user in expected and unchanging conditions for second aircraft, with an emphasis on rapid resupply.
Task III: 13 Months Option 2	Adapt sensor package and supervisory control system to handle a cargo mission in unexpected and dynamic conditions for first aircraft. Such conditions include contingency planning due to vehicle problems, dynamic changes in the environment including hostile fire, and/or weather changes such as thunderstorms. Update/Integrate the AACUS system hardware and software with the demonstration platform. Demonstrate the AACUS system

	capabilities on a single representative platform for a representative cargo mission in unexpected and dynamic conditions with a notional user.
Task IV: 11 Months Option 3	Demonstrate the AACUS system capabilities on two representative platforms simultaneously for a representative rapid resupply cargo mission in unexpected and dynamic conditions. Adapt sensor package and supervisory control system with integrated mission-centered global open architecture to handle cargo missions with unexpected and dynamic conditions for both demonstration platforms. Update/Integrate the AACUS system hardware and software as needed.
Task V: 12 Months Option 3	Transition open architecture software to government, develop a transition test plan for sensor package in conjunction with a DoD testing facility, finalize open architecture cost-benefit analysis, and draft lessons learned.

3 Requirements

3.1 Systems Engineering/Program Management

The following Systems Engineering and Program Management (SE/PM) tasks shall be applied across all tasks (Tasks I-V) for the program:

3.1.1 Program Management

The contractor shall maintain a single management focal point with decision authority and maintain a supporting program management system to control and manage cost, schedule, performance, and risk during the lifecycle of the project. The Contractor shall develop, maintain and update an Integrated Master Schedule. The Contractor shall develop and apply a management approach for the program that defines clear lines of authority within the Contractor's organization. The Contractor shall be responsible for quality, cost and schedule management of all subcontractors used to perform tasks required by the contract. Applicable provisions of the contract shall be flowed down to subcontractors and enforced by the Prime contractor.

3.1.2 Configuration Management

The Contractor shall establish and implement a Configuration Control System that ensures product identification, change management (tracking, reporting, and accountability) and interface management. The contractor shall provide a contractor's Configuration Management Plan to the Government if requested.

3.1.3 Contract Work Breakdown Structure (CWBS)

The Contractor shall develop and maintain a product-oriented CWBS using DOD MIL-HDBK-881A as guidance. The contractor shall report at WBS level 3 at a minimum and should expand this to any level appropriate to facilitate internal management, surveillance, and performance measurements.

3.1.4 Integrated Master Schedule (IMS)

The Contractor shall update the IMS that was submitted with the proposal within thirty (30) days of contract award. Thereafter, the IMS shall be updated monthly at a minimum. The Contractor shall provide the Government electronic access to the IMS. Unless another format is specifically approved by the Government, the schedule will be in MS Project format.

The IMS shall be sufficiently detailed that critical and high-risk efforts are identified and mitigation efforts planned as realistically as possible to ensure program execution. The IMS will be extended and expanded as the contract, options, or agreements unfold and additional insight is needed (e.g., Government-approved scope changes).

The IMS shall include the efforts of all activities, including Contractor or supplier and sub-contractor. It shall display the critical path. The IMS shall also include, as a minimum: engineering development tasks, Contractor tests, design reviews, milestones, contract deliverable timelines, significant activities, Government tests, design and technical reviews, deliveries, and program reviews.

The IMS shall present a current, integrated view of the contract and the contractor shall notify the Government in writing of any anticipated or projected work stoppages or delays that will impact schedules. The Contractor shall provide an updated/current program schedule as part the Contractor's monthly status report.

3.1.5 Integrated Development Environment (IDE)

The Contractor shall implement an IDE with Government access to support effective communication and timely exchange of information. The Contractor shall submit data and deliverables in electronic format by posting it on a secure contractor-managed IDE, as well as to the Program Officer as requested.

3.1.6 Management Reports

3.1.6.1 Monthly Status Reports (MSR)

The Contractor shall provide a monthly status report in contractor format by the 10th of the month covering activities for the previous month. The report shall highlight accomplishments for the previous month, planned activities, cost, schedule, and performance status, and risks, issues, and concerns.

3.1.6.2 Semi-Annual Reports

The Contractor shall provide a semi-annual status report every six months after contract award. The report shall be in contractor format and provided by the 10th of the month following the six-month period. The report shall highlight accomplishments for the previous six months, planned activities, cost, schedule, and performance status, risks, issues, and concerns, and report on technology enhancements implemented or planned for implementation

3.1.6.3 Cost / Financial Status Report

Earned Value Management (EVM) is not a requirement for the program; however, the Contractor shall provide cost reporting on a monthly basis in contractor format showing funds expended, funds remaining, and projected Estimate at Complete (EAC). The Contractor shall provide a projected spend plan by month.

3.1.7 Management Reviews and Meetings

3.1.7.1 Bi-Weekly Program Management Telecons

The Contractor shall support bi-weekly program management telecons with the Government. The contractor shall discuss program accomplishments, risks, issues and concerns, and upcoming technical actions and events.

3.1.7.2 Bi-Weekly Technical Telecons

The Contractor shall support bi-weekly technical telecons with the Government. If an IPT structure is implemented for the program, each IPT lead should attend this telecon. The contractor shall discuss technical accomplishments, risks, issues, concerns, and upcoming technical actions. If appropriate, this telecon may be combined with the program management telecon.

3.1.7.3 Project Kickoff

The Contractor shall conduct a Project Kickoff meeting within thirty (30) days after contract award. The purpose of the meeting will be to establish relationships, review any contract ambiguities, and for the prime and subcontractors to review and demonstrate to the Government their management procedures for executing the contract and to establish schedule dates for near term critical meetings/actions. The Contractor shall present management, key personnel, and program implementation processes.

3.1.7.4 Quarterly Program Management Reviews (QPR)

The Contractor shall schedule Quarterly Program Reviews with the Government starting ninety (90) days after contract award. These QPRs will continue as needed for the life of the contract. The purpose of the QPR is to provide a top level management overview and cover work completed, performance, risks/mitigation, cost/schedule reporting, and contract/technical status and issues. The Contractor will prepare and distribute minutes to include action items in Contractor's format.

3.1.8 Quality Assurance

The Contractor shall maintain a Quality Assurance program that meets the intent of International Standards Organization (ISO) 9000. The Contractor's quality control system procedures and plans shall be available for Government review.

3.1.9 Technical Interchange Meetings (TIM)

The Contractor shall conduct TIMs, to be scheduled upon request of the responsible Contracting Officer or written designee, to discuss and to informally evaluate the Contractor's efforts and accomplishments in direct relation to this contract.

3.1.10 Risk Management

The Contractor shall develop a project Risk Management Plan (RMP) and conduct regular risk assessments of system cost, schedule and performance requirements. The Government shall participate in contractor risk meetings held IAW the RMP. Risks shall be reported monthly in the MSR.

3.1.11 Traceability Documentation

The Contractor shall establish a requirements traceability system to track system requirements.

3.1.12 Technical Performance Measurement (TPM)

The Contractor shall utilize TPMs to maintain status on the system's key technical performance. The Contractor shall define, with Government coordination, technical parameters for system TPMs. The Contractor shall recommend changes to the list of technical parameters as the system matures. The Contractor shall present TPM data to the Government at each QPR.

3.1.13 Engineering Data

The contractor shall prepare a Technical Data Package (TDP) containing all engineering data developed for the program and provide to the Government at the end of the program phase. The data shall consist of key product characteristics, engineering drawings, schematics, design configurations, system and product specifications, and parts and material lists.

3.1.14 Technical Reviews

3.1.14.1 System Requirements Review (SRR)

The Contractor shall prepare for and conduct an SRR. This review will be held to examine the functional and performance requirements defined for the system to ensure that the requirements and the selected concept will satisfy the mission. The review will include: system and performance requirements for the phase, develop a functional architecture, envision a physical architecture, develop the system level specification and draft product/subsystem specifications, establish TPMs, and identify test methods for requirements. The SRR will be a 2-day review in the VA/DC area. Material provided shall be distributed at a minimum 5 days in advance of the review.

3.1.14.2 Preliminary Design Review (PDR)

The Contractor shall prepare for and conduct a PDR. The PDR will be held to demonstrate that the preliminary design meets all system requirements with acceptable risk and within the cost and schedule constraints and establishes the basis for proceeding with detailed design. It will show that the correct design options have been selected, interfaces have been identified, and verification methods have been described. This includes at a minimum HW & SW design documents, trade studies, analysis, prototypes, simulations, test events, etc. A draft subsystem test plan shall be developed. The PDR will be a 2-day meeting in the VA/DC area. Review packages shall be distributed 5 days in advance of the review. The subcontractor's format is acceptable.

3.1.14.3 Critical Design Review (CDR)

The Contractor shall prepare for and conduct a CDR. The CDR will be held to demonstrate that the maturity of the design is appropriate to support proceeding with full-scale fabrication, assembly, integration, and test. CDR determines that the technical effort is on track to complete the flight and ground system development and mission operations, meeting mission performance requirements within the identified cost and schedule constraints This includes at a minimum HW & SW design documents, subsystem/component specs, trade studies, analysis, prototypes, simulations, test events, etc. The subsystem test plans shall be finalized. The CDR will be a 3-day meeting in the VA/DC area. Review packages shall be distributed 5 days in advance of the review.

3.1.14.4 Technology Maturation Plan (TMP)

The Contractor shall prepare a TMP in contractor format to address any technology area below Technology Readiness Level (TRL) 6 that is planned for use in this project. The TMP should address each area by providing the following:

- Describe the technology and its maturity status
- Describe how the technology will be used in the project
- Describe the benefit of using this technology
- Describe a "fall back" plan and options for accomplishing the goal if the technology cannot be matured to TRL 6 or above
- Describe key activities for using the technology
- Prototypes or EMD models planned
- Tests to be performed
- How the test environment relates to the operational environment
- Describe the threshold performance that must be met
- Describe the TRL level that will be achieved and when
- Describe preparation for using a "fall back" plan
- Identify the latest time that a "fall back" option can be chosen
- Discuss the status of funding for the technology maturation

3.1.15 Master Test Plan

The Contractor shall prepare and maintain a Master Test Plan that shall include a Verification Test Matrix cross-referenced to each of the requirements derived for the system and with the proposed method of compliance for each requirement. The MTP shall describe the contractor's plan for conducting tests and collecting and analyzing test results to show how the system will satisfy the requirements of the applicable design. The MTP shall also contain the test scenarios planned for the project.

3.1.16 Software Documentation

The Contractor shall formally document its software design and coding efforts in a Software Design Document (SDD). The SDD shall contain the data, architecture, interface, and procedural design at a minimum.

3.1.17 Software Reporting

For all software failures/deficiencies, the Contractor shall be responsible for software trouble/problem report tracking using the Contractor's specified software trouble/problem tracking tool. The Contractor shall provide Configuration Management (CM) for the system software. Any software failures/deficiencies will be identified, tracked, prioritized, recorded, and closed as determined by the requirements in the CM plan.

3.1.18 Software Qualification Testing (SQT)

The Contractor shall perform SQT for the system. SQT shall demonstrate the capabilities in the Contractor's System Performance Based Specification. The Contractor shall submit a Software Test

Description and Software Test Plan in contractor's format. The results of SQT shall be documented in a final Software Test Report and delivered to the Government.

3.1.19 Safety and Health Hazards

The Contractor shall identify and evaluate system safety and health hazards; define risk levels; and establish a program that manages the probability and severity of all hazards associated with the project. Safety and health hazards shall be managed consistent with mission/system requirements. Inherent hazards shall be identified, evaluated, and either eliminated or controlled to ensure minimum risk to the environment and personnel. The safety and hazard analysis shall be documented in a Safety Assessment Report (SAR) in contractor format. The SAR shall document the safety risk being assumed prior to training, test, or operation of the system. The SAR shall identify safety features of the system hardware and software design, specific controls or precautions to be followed in the use of the system, and shall provide verification of compliance to any safety requirements identified for the project.

3.2 Development

3.2.1 AACUS General Requirements

The following are general system requirements to be developed across the program. Since this is a science and technology program attempting to advance the state-of-the-art in a high-risk setting, it is recognized that some requirements are vague and may stretch the limits of the possible. The contractor should endeavor to mature the system capabilities as much as possible within the budget and timeframe provided. Some requirements may require negotiation at the System Requirements Reviews; however, scope increases and or changes will be handled via ONR contracts.

3.2.1.1 The AACUS-enabled platform should be able to autonomously detect and execute a landing to an unprepared site while simultaneously negotiating and navigating threats and obstacles, potentially requiring evasive maneuvering.

3.2.1.2 The AACUS-enabled platform should be able to autonomously avoid obstacles (both static and dynamic) in flight as well as in the descent-to-land phase in a potentially GPS-denied environment. The primary focus of AACUS is the approach, descent, and land phase so the intent for obstacle avoidance is to consider navigation in low level flight envelopes. Such obstacles could be static (i.e., towers) or dynamic, (i.e., no flight zones due to enemy activity). It should be noted that this does not include avoiding other aircraft via a sense/see and avoid system.

3.2.1.3 The AACUS-enabled platform should be able to detect and negotiate any obstacle that could prevent a safe approach and landing (safe ground composition i.e. marsh vs. field, vegetation, and water) and able to negotiate sloped landing sites.

3.2.1.4 The AACUS-enabled platform shall be capable of generating complete paths from takeoff to landing, modifiable by a human in a supervisory control role in real-time.

3.2.1.5 This platform should also generate and execute new paths as required by mission contingencies.

3.2.1.6 The AACUS-enabled platform shall be capable of goal-based supervisory control with an unobtrusive device from a variety of end-users with no specialized training as well as from various locations (field personnel, medical personnel, supply personnel, command center personnel), which could be Beyond-Line-of-Sight (BLOS) from the launch location.

3.2.1.7 The AACUS-enabled platform should allow an operator with no special skills to supervise and request services from the system.

3.2.1.8 The AACUS-enabled platform should be able to operate in environments that present significant risks to manned aircraft today (i.e., weather, threat, terrain, etc.), and ideally operate in environments that manned aircraft cannot (i.e., high wind, steep terrain, low visibility), etc.)

3.2.1.9 The AACUS-enabled platform should be able to be monitored and supervised through a more traditional ground control station with mission planning capabilities from a remote operations center.

3.2.1.10 The AACUS-enabled platform should be able to operate in meteorological or operating conditions that may limit manned cargo delivery especially in austere terrains with a similar platform in Instrument Meteorological Conditions (IMC) and non-icing conditions with minimum visibility due to dust, precipitation, and fog.

3.2.1.11 The contractor shall develop a sensor package and supervisory control system that can be integrated and physically mounted on a number of different Vertical Take Off and Landing (VTOL) platforms.

3.2.1.12 The contractor shall develop a Global Open Architecture Layer (GOAL) to allow portability of the AACUS capability to other platforms (a minimum of two different platforms is required.)

3.2.1.13 The contractor shall execute multiple demonstrations of the AACUS technologies on two separate airframes in progressively challenging scenarios as the system is matured over the program timeline.

3.2.2 Platform Desired Capabilities

The basic desired capabilities for an AACUS-enabled platform are described below. These are guidelines instead of strict specifications.

3.2.2.1 The general air vehicle type is expected to operate at low density, high altitudes (greater than 12,000 ft density altitude), delivering multiple in-stride cargo drops, over round trip distances with a threshold of 150 nautical miles and an objective of 365 nautical miles, therefore reducing the number of ground transport delivered items.

3.2.2.2 The air vehicle should be one that can carry a threshold of 1600 lbs and an objective of 5000 lbs of payload internally (with some internal capacity for casualty evacuations).

3.2.2.3 The air vehicle is required to travel at speeds of 110 knots threshold and 250 knots objective. Within the terminal area of 5 nautical miles, the air vehicle should be able to descend and land within a threshold of 4 minutes and an objective of 2 minutes and execute an autonomous landing as close to the requested site as possible (<1 m error from computer-designated landing site center point) without over-flight of the landing zone (i.e., the vehicle executes a straight-in approach).

3.2.2.4 In addition, the air vehicle shall be able to operate at night (24/7) in possibly satellite-denied settings, and in all types of environments including steep and rugged terrain, Instrument Meteorological Conditions (IMC) and non-icing conditions, high and hot environments, and in dust and sand conditions with minimum visibility. An AACUS-enabled vehicle should be able to operate in weather conditions that exceed manned flight capabilities.

3.2.3 Specific Effort by Task

This section outlines task elements constructed by first considering the primary areas of work (Perception, Planning, Human-System Interfaces, GOAL, System Engineering, Integration & Test, and Transition), and creating sub-tasks in these areas to meet the goals of the program. The goals of the program were generated as a progression of capabilities, broken into major technical areas, as well as requirements for each capability area that increase the complexity of the AACUS mission as the program proceeds.

The proposal provided a top-level view of the progression of technical goals broken out by technical category. This is repeated in Figure 1 for reference. As part of the development of this table, the Aurora team created a more detailed plan for the level of capability required for each technology area. This is given in Table 1. Note that the levels of capability called out are for *Integrated Demonstration.* Together these tables provide an overview of the Aurora team's view of how the program should proceed and the goals at each stage of the program. This progression of goals has been translated into tasks in the work statement.

Note also that this set of goals is an estimate of the goals to be pursued, subject to progress made and discussions with the USMC. Consistent with the concept of a high-risk Science and Technology project, our approach in this SOW is to set the goals very high, understanding that achieving these goals is subject to technical uncertainties that will affect development time and the details of the ultimate demonstrations. For instance, parameters may change based on discussions with USMC, including terrain slope, vegetation to be addressed, and the presence of water. Short-duration GPS- denied situations will initially be addressed in unit tests using a sufficiently high-grade IMU, and dust and wind conditions above those called out will be attempted. Wave-off signaling may be performed during the base plan using techniques that are simplified from a technical perspective, but require additional equipment or line-of-sight from the ground.

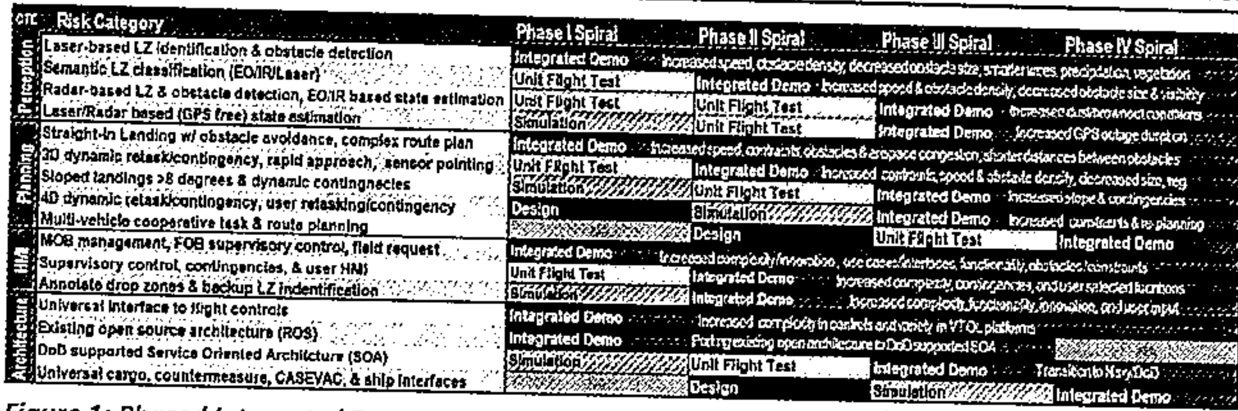


Figure 1: Phased Integrated Demonstration Plan. Phased plan for new capabilities including increasing complexity of dynamics, terrain, & environments for resupply operations in forward operating posts.

Domain	Task I Base (18 mo.)	Task II Option 1 (11 mo.)	Task III Option 2 (13 mo.)	Task IV Option 3 (11 mo.)
CONOPS				
Supply Type	Rapid Re-supply	Rapid Re-supply	Dynamic & Rapid	Dynamic & Rapid
Retasking	No	No	Yes	Yes
EMCON	No	No	No	Yes
Other	NA	NA	NA	CASEVAC
Mission Requirements				
cruise speed	80-100 kts	100 kts	Platform max	Manned (250 kts) Autonomous(platform max)
Approach (speed, descent)	30-50 kts	50-80 kts	80-100 kts	emergency (sim)
Altitude	sea-level to HOGE	sea-level to HOGE	sea-level to HOGE	~12 kft (above HOGE)
Weight Class	medium	heavy	medium or heavy	both
Terrain				
Roughness	~12 inches	~6 inches	~6 inches	~6 inches
Slope	up to 5 deg	up to 8 deg	platform max	platform max
Approach set-up	2-Way helispot	2-way helispot	1-way helispot	Constrained
Wires	None	Thick (power lines, >1")	> 0.25"	>0.25"
Obstacle size	3' high	1.5' high	1.5' high	> 0.5' high
Obstacle density	3 rotor radius spacing	3 rotor radius spacing	2 rotor radius spacing	2 rotor radius spacing
Vegetation	none	high variability	med variability (> 12")	low variability (6")
Water	none	sparse	sparse	water/snow/ice
Landing Zone Site	med radius from spot	med radius from spot	small radius from spot	tight restriction from spot
Physical Environment				
Period of Day	Day	Day	Day/night	Day/night
Wind	10kts gusting to 18 kts	15 kts gusting to 25 kts	15 kts gusting to 25 kts	platform limits
Precipitation	limited/none	0.5"/12 hours	1"/12 hours	2"/12 hours
Fog	limited/none	2000 ft visibility	1000 ft visibility	500 ft visiblity
Dust	light (TBD spec)	medium (TBD spec)	medium (TBD spec)	brownout
RF	some GPS/C2 denial	no GPS/C2 on final	GPS intermittent	No GPS or C2
Dynamic airspace	passive	limited	2-AV, weather, threat	congested
Threat	limited/none	known locations	pop-up, dynamic	heavy, dynamic
C2-Tasking Envir.				
Number of Aircraft	1	1	1	2
Contingencies	lost comms	lost comms	unplanned landing	multiple
Users (#/roles)**	OC, FU	OC, FU, LM	OC, FU, LM, VM	OC, FU, LM, VM, MED
Negotiation	simple	medium	complex	complex
Engine Out	No	No	No	sim

** Operations Center = OC, Field User = FU, Load Master = LM, Vehicle Mounted = VM, AV= Air Vehicle

Table 1 – AACUS Integrated Demonstration Plan

3.2.3.1 Document Outline By Task

The task outline is organized by program phases:

1: Task I (Base Program)
2: Task II (Option 1)
3: Task III (Option 2)
4: Task IV (Option 3)
5: Task V (Option 3)

The first 4 program tasks are broken down into several sub-areas:

1: Perception
2: Planning
3: Human-Systems Interfaces
4: GOAL
5: Systems Engineering, Integration, & Test

For the program Task V, the focus is entirely on Transition.

The numbering system is thus X.Y.Z, where X is the major program task (i.e., Task I, II, III, IV, or V), Y is the sub-area (i.e., Perception, Planning, etc), and Z is the work task within that sub-area.

3.2.4 Platform Selection and Flight Demonstration Location By Task

Task	Platform	Demonstration Location
I	Sikorsky S-76B	Primary: Warrenton, VA Alternate: Quantico, VA
II	AFDD JUH-60A RASCAL	Primary: Moffet Field/Ft Hunter Liggett, CA Alternate: Quantico, VA
III	Sikorsky S-76B	Primary: Warrenton, VA Alternate: Quantico, VA
IV	Sikorsky S-76B and AFDD JUH-60A RASCAL	Primary: Warrenton, VA Alternate: Quantico, VA

1 Base (Task I)

1.1 Perception

1.1.1 The Contractor shall develop a set of sensing subsystem requirements (including those for the EO/IR, Radar, and LIDAR subsystems) to satisfy the AACUS attributes.

1.1.2 The Contractor shall perform the necessary integration and testing to support demonstration of sensor fusion, enabling landing zone identification and terminal area obstacle detection as part of the Task I integrated demonstration. Daylight conditions, with some ambient dust and limited visibility.

1.1.3 The Contractor shall perform development and testing to support LZ identification and obstacle detection in daylight conditions, with some dust and limited visibility for Task I demonstration.

1.1.4 The Contractor shall perform development and testing to support detection and avoidance of large (55 gallon drum sized, about 3 ft. high) obstacles distributed with medium density (spaced as low as 3 rotor diameters apart, e.g. 1 rotor diameter on either side of vehicle to nearest obstacle) for Task I demonstration.

1.1.5 The Contractor shall perform development and testing to support landing zone identification, distinguishing and avoiding surfaces of medium roughness (~12 inch resolution), for Task I demonstration. The Contractor will conduct testing to show subsequent wave-off from unsafe terrain as part of the Task I integrated demonstration.

1.1.6 The Contractor shall perform the necessary integration and testing to perform unit flight testing of semantic classification of terrain in the LZ using EO, IR, and Laser data as appropriate. Unit flight tests will be performed separate from the integrated Task I demonstration.

1.1.7 The Contractor shall perform the necessary integration and testing to perform limited unit flight testing of Radar-based LZ and obstacle detection. Unit flight tests will be performed separate from the integrated Task I demonstration.

1.1.8 The Contractor shall perform the necessary integration and testing to perform limited unit flight testing of EO/IR based state estimation, and understanding sensing in dust. Unit flight tests will be performed separate from the integrated Task I demonstration.

1.1.9 The Contractor shall perform unit flight testing of GPS-free state estimation using the AACUS baseline system, as well as simulations of Laser/Radar-based (GPS free) state estimation.

1.2 Planning

1.2.1 The Contractor shall develop the trajectory planning and control terminal obstacle avoidance methods, including negotiation and navigation of threats and obstacles and evasive maneuvering, necessary to implement complex, high speed approaches using perception-based landing site selection results. Initial versions of these methods will command landing trajectories from 80-100 kts cruise speed, followed by a slow (30-50 knots) straight-line approach (single pass) and landing to an unprepared landing site for Task I demonstration.

1.2.2 The Contractor shall perform development and testing to support detection and en route trajectory planning and maneuvering to avoid large (large towers, mountains) obstacles distributed with low density (single encounters along flight path) for Task I demonstration.

1.2.3 The Contractor shall perform development and testing of trajectory planning and control to support landing at a 2-way helispot[1] with a clear radius of 3 rotor diameters (large radius) and a slope of up to 5 deg for Task I demonstration.

1.2.4 The Contractor shall perform development and testing of trajectory planning and control to support landing in medium winds (10 knots, gusting to 18 knots) with limited/no threats from the ground for Task I demonstration.

1.2.5 The Contractor shall develop a baseline mission and route planning method consistent with rapid resupply CONOPs.

1.2.6 The Contractor shall perform simulation studies to develop methods for landing on highly sloped surfaces (near platform limits), and maneuvering to adjust to dynamic contingencies and wind conditions.

1.2.7 The Contractor shall perform initial design activities for methods to perform dynamic retasking including moving constraints, and contingency handling for en route path planning problem based on user inputs, unforeseen events, and dynamic/moving threats.

1.3 Human System Interface (HSI)

Cognitive Task Analysis (CTA) and focused interviews with end users at the MOB, FOB and COP are an integral part of the Aurora HSI development process, and will inherently drive changes in the notional design. That is, the HSI design and development methodology acts as a feedback mechanism to ensure that the HSI evolves and improves over time as the collective team pushes the limits of system autonomy. The following requirements are written to provide a baseline set of performance parameters and to handle known contingency operations such as lost link. However, the requirements also provide the contractor leeway in creating innovative solutions to satisfy each requirement. For budgetary

[1] A *2-way helispot* in this document refers to a location that has been chosen by the autonomy to incorporate a wave-off and/or take-off direction that has approximately the same heading as the landing heading, so that the helicopter does not have to pirouette to take off again. It is not a prepared landing site in any sense. In contrast, *one-way helispot* is constrained in the outgoing direction, so it is more difficult to wave-off from, and presents more challenges for choosing take-off and landing directions. The term 'helispot' as used here does not imply any preparation of the landing site, rather it describes the geometry/geography of the LZ.

purposes, the Contractor team chose a baseline set of hardware and software technology to compute a budget. However, if the Human Factors analysis dictates a change to the HSI, the contractor may change the software and/or hardware as long as the budget constraints are not violated and the requirement is met.

1.3.1 The contractor shall perform in-depth analysis of the AACUS mission, CONOPs, and related field expertise (e.g. SMEs) to develop a 'cognitive system' of agents, both human and autonomous, that work together as a team to efficiently and flexibly perform complex resupply missions.

1.3.2 The Contractor shall analyze the roles and cognitive tasks associated with the AACUS mission. Subject matter experts will be interviewed to elicit knowledge of the operational conditions and potential roles in the AACUS mission.

1.3.3 The Contractor shall perform a system-level cognitive design exercise to develop an architecture for the interacting human and autonomous agents, their roles, and necessary interfaces for carrying out the AACUS mission.

1.3.4 The Contractor shall utilize the overall human-machine system architecture, human tasking and support, and cognitive task analysis results to develop traceable requirements for the HSIs to be developed for the AACUS project. During Task I, focus will be on the field user (COP) and the MOB interfaces, with higher-level description of FOB and vehicle-mounted interfaces.

1.3.5 The Contractor shall design prototype HSIs for use by the field user (COP request), to provide goal-based supervisory control with an unobtrusive device from a variety of end-users with no specialized training as well as from various locations (field personnel, medical personnel, supply personnel, command center personnel), which could be Beyond-Line-of-Sight (BLOS) from the launch location. Requirements developed during Cognitive Task Analysis will be applied, as well as use cases and operator feedback. A prototype of the interface will be developed and integrated into the AACUS command control system for Task I demonstration.

1.3.6 The Contractor shall incorporate lost communications protocols and simple Operations Center/Field User negotiations in the COP HSI design.

1.3.7 The Contractor shall design an initial HSI concept for use at the main operating base. The MOB HSI shall allow the operator to develop mission plans, monitor execution, maintain situation awareness of the vehicle state and threats to the mission plan, and perform replanning when necessary. Requirements developed during cognitive system design will be applied. A functional interface will be developed.

1.3.8 The Contractor shall incorporate lost communications protocols and simple Operations Center/Field User negotiations in the autonomy and MOB HSI design

1.3.9 The Contractor shall perform preliminary HSI development for the FOB. Requirements developed during CTA will be applied, as well as use cases and operator feedback. Story boards and related approaches for walk-through evaluation of the interface will be developed.

1.4 Global Open Architecture Layer

1.4.1 The contractor shall begin development of a Global Open Architecture Layer (GOAL) to allow portability of the AACUS capability to other platforms (A minimum of two different platforms is required for the program, but only one for Task I.)

1.4.2 The Contractor shall develop an interface to the vehicle flight controls and vehicle management system. The functional and interface architecture will be developed, and implementation sufficient to carry out Task I demonstration shall be carried out.

1.4.3 The Contractor shall utilize the existing Robot Operating System (ROS) architecture for data distribution and sharing. Software integration and sensor interfaces sufficient to for execution of the Task I demonstration shall be carried out.

1.4.4 The Contractor shall develop a plan for implementing the AACUS software under a Service-Oriented Architecture, and for transitioning ROS-based software elements into this architecture. Software development will begin under Task I, with the goal of utilizing the SOA for transition of software elements from the Task I AACUS vehicle to the AMRDEC/AFDD UH-60 RASCAL for Task II.

1.5 Integration & Test

1.5.1 The contractor shall develop a System Requirements Document, including Technical Performance Measures, for the program in coordination with ONR personnel.

1.5.2 The Contractor shall plan and perform the comprehensive system engineering, avionics architecture development and open-architecture integration of an AACUS system (sensor package and supervisory control system to execute the AACUS CONOPs) that can be physically mounted on, and integrated into, at least two different VTOL platforms. During this Phase, integration onto one such platform will be executed.

1.5.3 The Contractor shall perform all required communication subsystem integration and test to support AACUS flight testing

1.5.4 The Contractor shall perform integration, ground test, and evaluation activities required to validate all of the sensor and avionics subsystems in preparation for flight testing.

1.5.5 The Contractor shall prepare a Master Test Plan, including a comprehensive test plan for the flight test events.

1.5.6 The Contractor shall perform necessary simulation, hardware in the loop testing, analytical and simulation validation to prepare for flight testing. Simulation and testing events will be performed often to show incremental improvements over time.

1.5.7 The Contractor shall develop ground test events and associated test readiness reviews, and report on results.

1.5.8 The Contractor shall develop the necessary flight test plans and obtain the necessary flight clearances to enable safe, successful, cost-effective flight testing.

1.5.9 The Contractor shall implement a formal process for flight test planning, readiness reviews, and pre-flight check to ensure safe, successful flight tests.

1.5.10 The contractor shall select a range suitable for the flight demonstration and make arrangements with the range to secure the time, facilities, and support required for the flight demonstration. All necessary flight and frequency clearances to perform the flight demonstration will be obtained.

1.5.11 The contractor shall perform a series of flights as a final demonstration of the AACUS system during this Task. Ideally, these flights shall be the minimum needed and will occur over a day, weather and safety permitting.

1.5.12 The Contractor shall provide a quick look demonstration test report, due 10 days after the event, and a comprehensive flight demonstration test report, due 30 days after the event.

2 Option 1 (Task II)

2.1 Perception

2.1.1 The Contractor shall upgrade the laser-based LZ identification & obstacle avoidance to operate in limited precipitation (0.5 in/12 hour) and/or light fog (visibility 2000 ft), and medium dust (TBD spec) conditions for Task II demonstrations.

2.1.2 The Contractor shall upgrade the laser-based LZ identification and obstacle detection capabilities to enable detection and avoidance of medium (1.5 feet, e.g. 55 gallon drum on its side, boxes, or medium boulders) obstacles distributed with medium density (spaced as low as 3 rotor diameters apart) for Task II demonstration.

2.1.3 The Contractor shall perform development and testing to support detection and avoidance of thick wires (power lines of diameter greater than 1 inch) for Task II demonstration.

2.1.4 The Contractor shall upgrade the laser-based LZ identification capabilities to enable distinguishing surfaces of low roughness (~6 inch resolution) for Task III demonstration.

2.1.5 The Contractor shall perform the necessary integration and testing to support demonstration of semantic classification of terrain in the LZ and subsequent autonomous rejection of and go-round from unsafe terrain as part of the Task II integrated demonstration.

2.1.6 The Contractor shall perform development and testing to support semantic classification of terrain in daylight conditions, with precipitation (0.5" in 12 hours), fog (2,000 ft visibility), or dust (medium) for Task II demonstration (Option 1 in the table).

2.1.7 The Contractor shall perform development and testing to support semantic classification of highly variable vegetation (tree copses, large bushes, etc.) for Task II demonstration.

2.1.8 The Contractor shall perform the necessary integration and testing to complete the unit flight testing phase of Radar-based LZ and obstacle detection. Unit flight tests will be performed separate from the integrated Task II demonstration.

2.1.9 The Contractor shall upgrade the Radar-based LZ identification & obstacle avoidance to operate in light precipitation (0.5 in/12 hour) and/or light fog (visibility 2000 ft), and light dust (TBD spec) conditions for Task II unit testing.

2.1.10 The Contractor shall perform the necessary integration and testing to complete the unit flight testing phase of EO/IR based state estimation. Unit flight tests will be performed separate from the integrated Task II demonstration.

2.1.11 The Contractor shall perform development and testing to support EO/IR based state estimation in daylight conditions, with no precipitation, fog, or dust, for Task II unit testing.

2.1.12 The Contractor shall perform development and testing to support EO/IR based state estimation with no GPS or C2 on final approach, for Task II unit testing.

2.2 Planning

2.2.1 The Contractor shall upgrade trajectory planning and control to support landing at a 2-way helispot[2] with a clear radius of 3 rotor diameters (medium radius) and a slope of up to 8 deg for Task II demonstration.

2.2.2 The Contractor shall upgrade the approach trajectory generation and control methods to support landing trajectories from at least 100 kts cruise speed, followed by a medium speed (50-80 knots) straight-line approach (single pass) for Task II demonstration.

2.2.3 The Contractor shall upgrade the trajectory planning and control to support landing in high winds (15 knots, gusting to 25 knots) with known threats from the ground for Task II demonstration.

2.2.4 The Contractor shall upgrade the detection and en route trajectory planning and maneuvering capabilities to enable detection and avoidance of medium (e.g. radio towers) obstacles distributed with medium density (at most two simultaneous encounters) for Task II demonstration.

2.2.5 The Contractor shall develop the dynamic 3D en route path planning methods to translate mission goals into high-level waypoint-based plans from takeoff to landing, modifiable by a human in a supervisory control role in real-time, including methods to route around en route obstacles such as terrain, no-fly zones, weather, and threats in the context of a Rapid Resupply mission. These methods will be unit tested during Task II. Unit flight tests will be performed separate from the integrated Task II demonstration.

2.2.6 The Contractor shall develop 3D dynamic and en route routing, retasking and contingency handling to support medium winds (10 knots, gusting to 18 knots), limited airspace activity, and no pop-up contingencies for Task II Unit testing.

2.2.7 The Contractor shall develop 3D dynamic and en route routing, retasking and contingency handling to support lost communications and operator/airspace negotiations including the OC, FU, and Load Master, for Task II unit testing.

2.2.8 The Contractor shall perform unit flight testing of methods enabling landing on highly sloped surfaces (near platform limits) and maneuvering to adjust to dynamic contingencies and wind conditions. Unit flight tests will be performed separate from the integrated Task II demonstration.

2.2.9 The Contractor shall perform development and testing of landing on highly sloped surfaces and maneuvering in medium winds (10 knots, gusting to 18 knots) for Task II demonstration.

2.2.10 The Contractor perform simulation demonstration of methods to perform dynamic retasking including moving constraints, and contingency handling for en route path planning problem based on

[2] See note 1, page 21.

user inputs, unforeseen events, and dynamic/moving threats. Rerouting around other vehicles following known and unchanging trajectories, and slowly moving weather and threat zones will also be accommodated.

2.2.11 The Contractor shall perform the necessary development and integration to perform replanning, with potentially moving constraints, for contingencies including lost communications, dynamic retasking en route, and negotiations between the OC, FU, and LM.

2.3 Human System Interface

2.3.1 The Contractor shall perform initial design activities for methods to perform multi-vehicle cooperative tasking and deconflicted routing.

2.3.2 The Contractor shall continue to develop and evolve the HSIs for use by field users and ground crew at the COP, allowing an operator with no special skills to supervise and request services from the system. Operationally authentic scenarios and use cases will be used in walk-through assessments and flight tests to increase the complexity of negotiations addressed. The field user HSI shall allow an operator with minimal training to request service using the knowledge base regarding location, terrain, weather, and threats typically available to an expeditionary force marine. Integration into the command control system will be conducted, for Task II demonstration.

2.3.3 The Contractor shall address backup landing zone identification, as well as other tools for communication of directions to the AACUS vehicle in the COP HSI design. More complex negotiations between the OC, FU, LM, and VM-autonomy will be enabled in the HSI design. Demonstration of the capability for complex negotiations will be conducted, to include the VM-mounted interface.

2.3.4 The Contractor shall continue to develop and evolve the HSI for use at the MOB. Operationally authentic scenarios and use cases will be used in walk-through assessments, operator feedback and data gathering flight tests to increase the complexity of negotiations addressed. Integration of a prototype into the command control system will be conducted, for Task II demonstration.

2.3.5 The Contractor shall continue to develop and evolve the HSI to be used at the MOB. Added mission complexity and innovative interface concepts will be incorporated. Integration into the command control system will be conducted, for Task IV demonstration.

2.3.6 The Contractor shall address more complex negotiations between the OC, FU, and LM in the MOB HSI design.

2.4 Global Open Architecture Layer

2.4.1 The Contractor shall transition the universal interface developed under Task I to the vehicle flight controls and vehicle management system of the AFDD UH-60 RASCAL. Further maturation of the software will be carried out, as well as implementation sufficient to perform Task II demonstration.

2.4.2 The Contractor shall integrate and mature the existing ROS open architecture software into the GOAL for AACUS. This GOAL will be implemented and utilized to enable transition of the AACUS system to the UH-60 RASCAL.

2.4.3 The Contractor shall perform unit flight tests of the Service Oriented Architecture as part of the GOAL-based implementation of the AACUS system on the UH-60 RASCAL.

2.5 Integration & Test

2.5.1 The Contractor shall plan and perform the comprehensive avionics architecture development and integration required for incorporation and flight testing of the AACUS system on the UH-60 RASCAL rotorcraft test platform.

2.5.2. The Contractor shall provide a quick look demonstration test report due 10 days after the event, and a comprehensive flight demonstration test report due 30 days after the event.

2.5.3 The Contractor shall perform all required communication subsystem integration and test on the UH-60 RASCAL to support AACUS flight testing

2.5.4 The Contractor shall perform integration, ground test, and evaluation activities required to validate all of the sensor and avionics subsystems in preparation for UH-60 RASCAL flight testing.

2.5.5 The contractor shall prepare a Master Test Plan, including a comprehensive test plan for the flight test events.

2.5.6 The Contractor shall perform necessary simulation, hardware in the loop testing, analytical and simulation validation to prepare for UH-60 RASCAL flight testing.

2.5.7 The Contractor shall develop ground test events, associated test readiness reviews and report on results.

2.5.8 The Contractor shall develop the necessary flight test plans and obtain the necessary flight clearances to enable successful, cost-effective flight testing

2.5.9 The Contractor shall implement a formal process for flight test planning, test readiness review, and pre-flight check to ensure successful flight tests.

2.5.10 The contractor shall select a range suitable for the flight demonstration and make arrangements with the range to secure the time, facilities, and support required for the flight demonstration. All necessary flight and frequency clearances to perform the flight demonstration will be obtained.

2.5.11 The contractor shall perform a series of flights as a final demonstration of the AACUS system during this Task. Ideally, these flights shall be the minimum needed and will occur over a day in conditions consistent with Task II, weather and safety permitting.

2.5.12 The Contractor shall provide a quick look demonstration test report due 10 days after the event, and a comprehensive flight demonstration test report due 30 days after the event.

3 Option 2 (Task III)

3.1 Perception

3.1.1 The Contractor shall upgrade the laser-based LZ identification and obstacle detection capabilities to enable detection and avoidance of medium size obstacles distributed with high density (spaced as low as 2 rotor diameters apart, e.g. one-half rotor diameter on either side to nearest obstacle) for Task III demonstration.

3.1.2 The Contractor shall upgrade the laser-based LZ identification & obstacle avoidance to operate at night, in medium precipitation (1 in/12 hour) and/or medium fog (visibility 1000 ft), and medium dust (TBD spec) conditions for Task III demonstrations.

3.1.3 The Contractor shall perform development and testing to support detection and avoidance of thin wires (diameter greater than 0.25 inch) for Task III demonstration.

3.1.4 The Contractor shall upgrade the semantic classification system to classify vegetation of medium variability (low brush and trees with variability > 12 inches) and sparse areas of water (one or two large bodies) for Task III demonstration.

3.1.5 The Contractor shall upgrade the semantic classification of terrain to operate in light precipitation (0.5 in/12 hour) and/or light fog (visibility 2000 ft), and light dust (TBD spec) conditions, for Task III demonstration.

3.1.6 The Contractor shall perform the necessary integration and testing to support demonstration of Radar-based LZ and obstacle detection as part of the Task III integrated demonstration.

3.1.7 The Contractor shall upgrade the Radar-based LZ identification & obstacle avoidance to operate at night, in medium precipitation (1 in/12 hour) and/or medium fog (visibility 1000 ft), and medium dust (TBD spec) conditions for Task III demonstrations.

3.1.8 The Contractor shall perform the necessary integration and testing to support demonstration of EO/IR based state estimation as part of the Task III integrated demonstration.

3.1.9 The Contractor shall perform development and testing to support EO/IR based state estimation with intermittent GPS during the entire mission, for Task III demonstration.

3.1.10 The Contractor shall upgrade the EO/IR based state estimation to operate in light precipitation (0.5 in/12 hour) and/or light fog (visibility 2000 ft), and light dust (TBD spec) conditions for Task III demonstration.

3.1.11 The Contractor shall upgrade the Laser/Radar based state estimation to operate in light precipitation (0.5 in/12 hour) and/or light fog (visibility 2000 ft), and light dust (TBD spec) conditions for Task III demonstration.

3.1.12 The Contractor shall perform the necessary integration and testing to support demonstration of Laser/Radar based (GPS free) state estimation as part of the Task III integrated demonstration.

3.1.13 The Contractor shall perform development and testing to support Laser/Radar based state estimation with no GPS or C2 on final approach, for Task III demonstration.

3.2 Planning

3.2.1 The Contractor shall upgrade the trajectory planning and control to support landing in high winds (15 knots, gusting to 25 knots or platform limits) with pop up threats from the ground that appear over a short time horizon (e.g. small arms fire) for Task III demonstration.

3.2.2 The Contractor shall upgrade the detection and en route trajectory planning and maneuvering capabilities to enable detection and avoidance of medium (radio towers) obstacles distributed with high density (spaced less than 20 rotor diameters apart) for Task II demonstration.

3.2.3 The Contractor shall upgrade the approach trajectory generation and control methods to support landing trajectories from the platform max cruise speed, followed by a fast (>80 knots) straight-line approach (single pass) for Task III demonstration.

3.2.4 The Contractor shall upgrade trajectory planning and control to support landing and take-off from a 1-way helispot[3] with a clear radius of 1.5 rotor diameters (small radius) and a slope which is the max allowable for the platform for Task III demonstration.

3.2.5 The Contractor shall develop 3D dynamic and en route routing, retasking and contingency handling to support greater than 100 kts cruise speed for Task III demonstration.

3.2.6 The Contractor shall develop 3D dynamic and en route routing, retasking and contingency handling to support high winds (15 knots, gusting to 25 knots), complex airspace activity including the Contractor's two AACUS platforms, and no pop-up weather and red force threats for Task III demonstration

3.2.7 The Contractor shall perform the necessary development and integration to perform 3D dynamic and en route routing, retasking and contingency handling (generate and execute new paths as required by mission contingencies) for the Task III demonstration.

3.2.8 The Contractor shall develop 3D dynamic and en route routing, retasking and contingency handling to support a Rapid Resupply scenario for Task III demonstration.

3.2.9 The Contractor shall upgrade 3D dynamic and en-route routing, retasking and contingency handling to support unplanned landings (en-route re-direction) and complex operator/airspace negotiations including the OC, FU, LM, and VM-autonomy for Task III demonstration.

[3] See note 1, page 21.

3.2.10 The Contractor shall perform the necessary development and integration to perform landing on highly sloped surfaces (near platform limits) and maneuvering to adjust to dynamic contingencies and wind conditions for the Task III demonstration.

3.2.11 The Contractor shall perform development and testing of perform landing on highly sloped surfaces and maneuvering in high winds (15 knots, gusting to 25 knots or platform limits) for Task III demonstration.

3.2.12 The Contractor shall perform development and testing of perform landing on highly sloped surfaces and maneuvering in medium winds (10 knots, gusting to 18 knots) for Task III demonstration.

3.2.13 The Contractor shall perform the necessary development and integration to perform dynamic retasking with moving constraints, and contingency handling for en route path planning for the Task III demonstration. The mission planner will be capable of performing en route replanning in response to dynamic threats and requests for service that occur after launch.

3.2.14 The Contractor shall develop the dynamic retasking with moving constraints, and contingency handling for en route path planning to handle the Contractor's two AACUS platforms in the airspace, some airspace congestion, and moving threats/weather patterns for Task III demonstration.

3.2.15 The Contractor shall perform the necessary development and integration to perform replanning, with potentially moving constraints, for contingencies including from lost communications, unplanned requests for landing, dynamic retasking en route, and complex negotiations between the OC, FU, LM, and VM-autonomy.

3.2.16 The Contractor shall perform unit flight testing of methods for multi-vehicle cooperative tasking and deconflicted routing. Unit flight tests will be performed separate from the integrated Task III demonstrations, with the flight vehicle coordinating with a number of simulated vehicles.

3.3 Human System Interface

3.3.1 The Contractor shall continue to develop and evolve the HSIs for use by the field user and ground crew at the COP. Added mission complexity and innovative interface concepts will be incorporated. The aircraft interface to field users shall allow field users to maintain situation awareness regarding the status of the incoming resupply vehicle during every phase of the mission, to initiate a wave-off (threshold) and other modifications (objective) to the landing, to approach the vehicle safely, and to signal when load/unload is complete and it is safe to take off. Integration of new features into the command control system will be conducted for Task III demonstration.

3.3.2 The Contractor shall further evolve the COP HSI design to allow for requests for replan including re-direction of en route vehicle for unplanned landings, annotation of drop zones, and complex negotiations between the OC, FU, LM, and VM-autonomy to address dynamic mission evolution.

3.3.3 The Contractor shall continue to develop and evolve the HSI for use at the MOB. TBD interfaces derived from CTA and SME studies, to support added mission complexity, will be incorporated. Integration into the command control system will be conducted, for Task III demonstration.

3.3.4 The Contractor shall further evolve the MOB HSI design to address complex contingencies, replanning including unplanned landings, and complex negotiations between the OC, FU, LM, and VM-autonomy to address dynamic mission evolution.

3.3.5 The Contractor shall continue to develop and evolve the HSI for use at the FOB. Added mission complexity and innovative interface concepts will be incorporated. Integration of a prototype into the command control system will be conducted for Task III demonstration.

3.3.6 The Contractor shall address lost communications protocols in the FOB HSI design, as well as other methods to provide operator input and directions to the AACUS vehicle autonomy. More complex negotiations between the OC, FU, LM, and VM-autonomy will be enabled in the HSI design.

3.4 Global Open Architecture Layer

3.4.1 The Contractor shall further evolve the universal interface to the flight control system, as part of the GOAL development and maturation.

3.4.2 The Contractor shall fully transition all AACUS software to the SOA GOAL architecture during Task III.

3.4.3 The Contractor shall perform design and development of a universal cargo, countermeasure, CASEVAC, and shipboard interface concept for incorporation into the AACUS vehicle. These software tools for on-vehicle cross-platform AACUS integration will be designed to enable transition of key AACUS functionality onto one or more relevant Navy/Marine Corps platforms in the future.

3.5 Integration & Test

3.5.1 The Contractor shall upgrade the communications system as necessary to support Task III flight testing

3.5.2 The Contractor shall provide a quick look demonstration test report due 10 days after the event, and a comprehensive flight demonstration test report due 30 days after the event.

3.5.3 The Contractor shall perform any additional integration, ground test, and evaluation activities required to prepare for Task III flight testing. This activity feeds into the TRR.

3.5.4 The contractor shall prepare a Master Test Plan, including a comprehensive test plan for the flight test events.

3.5.5 The Contractor shall perform necessary simulation, hardware in the loop testing, analytical and simulation validation to prepare for Task III flight testing.

3.5.6 The Contractor shall develop ground test events, associated test readiness reviews and report on results.

3.5.7 The Contractor shall develop the necessary flight test plans and obtain the necessary flight clearances to enable successful, cost-effective flight testing.

3.5.8 The Contractor shall implement a formal process for flight test planning, readiness review, and pre-flight check to ensure successful flight tests.

3.5.9 The contractor shall select a range suitable for the flight demonstration and make arrangements with the range to secure the time, facilities, and support required for the flight demonstration. All necessary flight and frequency clearances to perform the flight demonstration will be obtained.

3.5.10 The contractor shall perform a series of flights as a final demonstration of the AACUS system during this Task. Ideally, these flights shall be the minimum needed and will occur over a day, consistent with Task III conditions, weather and safety permitting.

4 Option 3 (Task IV)

4.1 Perception

4.1.1 The Contractor shall upgrade the laser-based LZ identification & obstacle avoidance to operate in heavy precipitation (2 in/12 hour) and/or heavy fog (visibility 500 ft), and brown-out dust (TBD spec) conditions for Task IV demonstrations.

4.1.2 The Contractor shall upgrade the laser-based LZ identification and obstacle detection capabilities to enable detection and avoidance of small (greater than a motorcycle) obstacles distributed with high density (spaced at least 2 rotor diameters apart) for Task II demonstration.

4.1.3 The Contractor shall upgrade the semantic classification system to classify low variability vegetation (grass, and uniform brush with variability <6 inches) as well as water, snow, and ice for Task IV demonstration.

4.1.4 The Contractor shall upgrade the semantic classification of terrain to operate at night, in medium precipitation (1 in/12 hour) and/or medium fog (visibility 1000 ft), and medium dust (TBD spec) conditions, , for Task IV demonstration.

4.1.5 The Contractor shall upgrade the Radar-based LZ identification & obstacle avoidance to operate in heavy precipitation 2 in/12 hour) and/or heavy fog (visibility 500 ft), and brown-out dust (TBD spec) conditions for Task IV demonstrations.

4.1.6 The Contractor shall upgrade the EO/IR based state estimation to operate at night, in medium precipitation (1 in/12 hour) and/or medium fog (visibility 1000 ft), and medium dust (TBD spec) conditions for Task IV demonstrations.

4.1.7 The Contractor shall upgrade the Laser/Radar based state estimation to operate at night, in medium precipitation (1 in/12 hour) and/or medium fog (visibility 1000 ft), and medium dust (TBD spec) conditions for Task IV demonstrations.

4.1.8 The Contractor shall perform development and testing to support EO/IR based state estimation with no GPS or C2 during the extended portions of the mission, for Task IV demonstration.

4.1.9 The Contractor shall perform development and testing to support Laser/Radar based state estimation with intermittent GPS during the entire mission, for Task IV demonstration.

4.2 Planning

4.2.1 The Contractor shall upgrade the approach trajectory generation and control methods to support landing trajectories from the platform max cruise speed (250 kts objective), for Task IV demonstration. Emergency approach and landing will be simulated as part of this task.

4.2.2 The Contractor shall upgrade trajectory planning and control to support landing and take-off from a constrained helispot[4] with a tightly restricted landing geometry for Task IV demonstration.

4.2.3 The Contractor shall upgrade the trajectory planning and control to support landing in at the wind limits of the platform with heavy, dynamic threats on the ground for Task IV demonstration.

4.2.4 The Contractor shall upgrade the detection and en route trajectory planning and maneuvering capabilities to enable the detection and avoidance of small (guy wires, high tension wires) obstacles distributed with high density (spaced less than 20 rotor diameter apart) for Task II demonstration.

4.2.5 The Contractor shall upgrade 3D dynamic and en route routing, retasking and contingency handling to support multiple vehicles, multiple contingencies, and more complex operator/airspace negotiations including medical emergencies for Task IV demonstration. Some scenarios may require 3D-plus-time (moving constraints) planning tools, which are covered in a separate task.

4.2.6 The Contractor shall upgrade the 3D dynamic and en route routing, retasking and contingency handling for the Task IV demonstration.

4.2.7 The Contractor shall upgrade the 3D dynamic and en route routing, retasking and contingency handling to support a Dynamic and Resupply scenario for Task IV demonstration.

4.2.8 The Contractor shall upgrade the 3D dynamic and en route routing, retasking and contingency handling to support an Emissions Controlled (EMCON) scenario for Task IV demonstration.

4.2.9 The Contractor shall develop 3D dynamic and en route routing, retasking and contingency handling to support platform limit winds (adaptable to match platform) for Task IV demonstration. Other challenging aspects of en route planning will be handled in Task IV by 3D-plus-time (moving constraints) and dynamic retasking methods.

4.2.10 The Contractor shall develop 3D dynamic and en route routing, retasking and contingency handling to support the platform maximum cruise speeds for Task IV demonstration.

4.2.11 The Contractor shall upgrade the dynamic retasking with moving constraints, and contingency handling for en route path planning to handle more complex moving constraints for the Task IV demonstration.

4.2.12 The Contractor shall upgrade dynamic replanning tools to be compatible with multiple vehicle coordination tools, and tested with two AACUS vehicles with multiple contingencies and complex negotiations. Engine out contingencies will also be addressed in simulation.

4.2.13 The Contractor shall upgrade the dynamic retasking with moving constraints, and contingency handling for en route path planning to handle congested airspace, and pop-up, moving threats for Task IV demonstration.

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[4] See note 1, page 21

4.2.14 The Contractor shall perform the necessary development and integration to perform multi-vehicle cooperative tasking and deconflicted routing for the Task IV demonstration with two live vehicles.

4.3 Human System Interface

4.3.1 The Contractor shall continue to develop and evolve the HSIs for use by the field user and ground crew at the COP. TBD interfaces derived from CTA and SME studies, to support added mission complexity, will be incorporated. Integration into the command control system will be conducted for Task IV demonstration.

4.3.2 The Contractor shall further evolve the COP HSI design to address multiple vehicle coordination, multiple dynamic contingencies including engine out, and complex negotiations arising from, for instance, from CASEVAC and hostile fire.

4.3.3 The Contractor shall further evolve the MOB HSI design to address multiple vehicle coordination, multiple dynamic contingencies including engine out, and complex negotiations arising from, for instance CASEVAC and hostile fire.

4.3.4 The Contractor shall continue to develop and evolve the HSI for use at the FOB. Added mission complexity and innovative interface concepts will be incorporated. Integration into the command control system will be conducted for Task IV demonstration.

4.3.5 The Contractor shall further evolve the FOB HSI design to allow for requests for replanning / unplanned landings, complex negotiations between the OC, FU, LM, and VM-autonomy, multiple contingencies and multiple vehicles, and dynamic mission evolution.

4.4 Global Open Architecture Layer

4.4.1 The Contractor shall integrate the universal cargo, countermeasure, CASEVAC, and shipboard interfaces onto the AACUS vehicle for Task IV demonstration.

4.4.2 The Contractor shall further mature the universal cargo, countermeasure, CASEVAC, and shipboard interface concept for incorporation into the AACUS vehicle. These software tools will be demonstrated on targeted simulations, using UH-60 RASCAL or other relevant vehicle specifications as a guide.

4.5 Integration & Test

4.5.1 The Contractor shall upgrade the communications system as necessary to support Task IV flight testing.

4.5.2 The Contractor shall provide a quick look demonstration test report due 10 days after the event, and a comprehensive flight demonstration test report due 30 days after the event.

4.5.3 The Contractor shall perform any additional integration, ground test, and evaluation activities required to prepare for Task IV flight testing. This activity feeds into the TRR.

4.5.4 The contractor shall prepare a Master Test Plan, including a comprehensive test plan for the flight test events.

4.5.5 The Contractor shall perform necessary simulation, hardware in the loop testing, analytical and simulation validation to prepare for Task IV flight testing.

4.5.6 The Contractor shall develop ground test events, associated test readiness reviews and report on results.

4.5.7 The Contractor shall develop the necessary flight test plans and obtain the necessary flight clearances to enable successful, cost-effective flight testing

4.5.8 The Contractor shall implement a formal process for flight test planning, readiness review, and pre-flight check to ensure successful flight tests.

4.5.9 The contractor shall perform a series of demonstrations involving simultaneous flight of two helicopters, with the AACUS system operating on each, during this Task as a final demonstration of the AACUS system during this Task. Ideally, these flights shall be the minimum needed and will occur over a day, weather and safety permitting.

4.5.10 The contractor shall select a range suitable for the flight demonstration and make arrangements with the range to secure the time, facilities, and support required for the flight demonstration. All necessary flight and frequency clearances to perform the flight demonstration will be obtained.

5 Option 3 (Task V)

5.1 Transition

5.1.1 The Contractor shall deliver a comprehensive Technical Data Package covering the technical development efforts in Tasks 1-4.

5.1.2 The Contractor shall prepare all program hardware for delivery and deliver to the Government. Delivery instructions will be provided in separate correspondence at a later date.

5.1.3 The Contractor shall support ONR developing an overall system transition strategy. Topics may include Concept of Operations, initial cost estimates, modeling and simulation requirements, residual use plan, user training, tools, test equipment, facility requirements, technical performance measures, spares, etc.

5.1.4 The Contractor shall support ONR developing system transition management plans. Plans may include supportability and sustainment, risk management, configuration management, product test, product improvement, product maturation, training, and metrics collection (effectiveness, suitability, reliability, producibility, supportability, cost, schedule, etc.).

5.1.5 The Contractor shall support ONR planning for a Military Utility Assessment. Planning topics may include identification of range, test facility requirements, system and platform requirements, training, cost estimates, etc.

5.1.6 The Contractor shall provide support as a member of a Transition Integrated Product Team.

5.1.7 The Contractor shall support ONR developing a proposal to obtain Technology Transition Initiative (TTI) funding.

5.1.8 The Contractor shall perform the necessary engineering tasks and prepare documentation, presentations, and provide other necessary support for obtaining airworthiness certifications for both rotorcraft platforms used during the AACUS program demonstrations.

5.1.9 The Contractor shall develop a transition plan for the open architecture software to be transitioned to the Government.

5.1.10 The Contractor shall develop a transition test plan for transitioning the sensor package to the Government (DoD testing facility).

5.1.11 The Contractor shall provide a cost-benefit analysis for the open architecture software. This shall include a trade space analysis for the design and implementation of the Global Open Architecture Layer.

5.1.12 The Contractor shall draft a lessons learned document that covers the entire program life.

3.3 Travel

The Contractor shall perform the travel necessary to successfully execute the program. To the extent possible, the contractor shall use the DoD Per Diem guidelines for travel costs.

3.4 Deliverables: Data, Meetings & Reviews

3.4.1 Base (Task I) Deliverables

Item #	Item Description - Data	Due Date	ONR Action
D101	Kickoff Meeting Presentation	30 days ARO	Review
D102	Monthly Technical and Financial Status Reports	20th working day of every month	Review
D103	Quarterly Program Review Presentations	Every quarter ARO	Review
D104	Semi-Annual Reports	Every 6 months ARO	Review
D105	Technology Maturation Plan	At PDR	Review
D106	System Requirements Review Presentation	Review Package 5 days Prior to SRR	Review
D107	Preliminary Design Review Presentation	Review Package 5 days Prior to PDR	Review
D108	Critical Design Review Presentation	Review Package 5 days Prior to PDR	Review
D109	Sensor Package Design for Demo Platform 1	As part of CDR	Approve
D110	Interface Control Document for Operations Center	Prelim. at CDR, final with final report	Approve
D111	Interface Control Document for Field User	As part of CDR	Approve
D112	Demonstration Test Plan	Draft at CDR. Final 30 days prior to demo.	Approve
D113	Test Readiness Review Presentation	Review Package 5 days prior to TRR	Review
D114	Demonstration Test Report	Quick Fire 10 Days after demo, Final 30 days after demo	Review

Item #	Item Description – Meetings & Reviews	Due Date	ONR Action
R101	Kickoff Meeting	30 days ARO	Attend
R102	Bi-Weekly program management telecons	As agreed bi-weekly	Attend
R103	Bi-Weekly Technical telecons	As agreed bi-weekly	Attend
R104	Quarterly Program Reviews	Every quarter ARO	Review
R105	System Requirements Review	As scheduled.	Approve
R106	Preliminary Design Review Presentation	As scheduled.	Approve
R107	Critical Design Review	As scheduled.	Approve
R108	Test Readiness Review	As scheduled.	Approve

3.4.2 Option 1 (Task III) Deliverables

Item #	Item Description - Data	Due Date	ONR Action
D201	Monthly Technical and Financial Status Reports	20th working day of every month	Review
D202	Semi-Annual Reports	Every 6 months ARO	Review
D203	Critical Design Review Presentation	Review Package 5 days Prior to PDR	Review
D204	Sensor Package Design for Demo Platform 2	As part of CDR	Approve
D205	Interface Control Document updates for operations center	As part of CDR	Approve
D206	Interface Control Document updates for the field user	As part of CDR	Approve
D207	Interface Control Document for vehicle-mounted displays for ground communication.	Prelim. at CDR, final with final report	Approve
D208	Demonstration Test Plan	Draft at CDR. Final 30 days prior to demo.	Approve
D209	Test Readiness Review Presentation	Review Package 5 days prior to TRR	Review
D210	Demonstration Test Report	Quick Fire 10 Days after demo, Final 30 days after demo	Review
D211	Global open architecture layer software (i.e., source code)	With Final Report	Review

Item #	Item Description – Meetings & Reviews	Due Date	ONR Action
R201	Bi-Weekly program management telecons	As agreed bi-weekly	Attend
R202	Bi-Weekly Technical telecons	As agreed bi-weekly	Attend
R203	Critical Design Review	As scheduled.	Approve
R204	Test Readiness Review	As scheduled.	Approve

3.4.3 Option 2 (Task III) Deliverables

Item #	Item Description - Data	Due Date	ONR Action
D301	Monthly Technical and Financial Status Reports	20th working day of every month	Review
D302	Semi-Annual Reports	Every 6 months ARO	Review
D303	Critical Design Review Presentation	Review Package 5 days prior to PDR	Review
D304	Updated Sensor Package Design for Demo	As part of CDR	Approve
D305	Interface Control Document updates for operations center	As part of CDR	Approve
D306	Interface Control Document updates for the field user	As part of CDR	Approve
D307	Interface Control Document updates for vehicle-mounted displays for ground communication.	As part of CDR	Approve
D308	Demonstration Test Plan	Draft at CDR.	Approve

		Final 30 days prior to demo.	
D309	Test Readiness Review Presentation	Review Package 5 days prior to TRR	Review
D310	Demonstration Test Report	Quick Fire 10 Days after demo, Final 30 days after demo	Review
D311	Updated Global open architecture layer software (i.e., source code)	With Final Report	Review

Item #	Item Description – Meetings & Reviews	Due Date	ONR Action
R301	Bi-Weekly program management telecons	As agreed bi-weekly	Attend
R302	Bi-Weekly Technical telecons	As agreed bi-weekly	Attend
R303	Critical Design Review	As scheduled.	Approve
R304	Test Readiness Review	As scheduled.	Approve

3.4.4 Option 3 (Task IV) Deliverables

Item #	Item Description - Data	Due Date	ONR Action
D401	Monthly Technical and Financial Status Reports	20th working day of every month	Review
D402	Semi-Annual Reports	Every 6 months ARO	Review
D403	Critical Design Review Presentation	Review Package 5 days prior to PDR	Review
D404	Updated Sensor Package Design for Demo	As part of CDR	Approve
D405	Interface Control Document updates for operations center	As part of CDR	Approve
D406	Interface Control Document updates for the field user	As part of CDR	Approve
D407	Interface Control Document updates for vehicle-mounted displays for ground communication.	As part of CDR	Approve
D408	Demonstration Test Plan	Draft at CDR. Final 30 days prior to demo.	Approve
D409	Test Readiness Review Presentation	Review Package 5 days prior to TRR	Review
D410	Demonstration Test Report	Quick Fire 10 Days after demo, Final 30 days after demo	Review
D411	Updated Global open architecture layer software (i.e., source code)	With Final Report	Review

Item #	Item Description – Meetings & Reviews	Due Date	ONR Action
R401	Bi-Weekly program management telecons	As agreed bi-weekly	Attend
R402	Bi-Weekly Technical telecons	As agreed bi-weekly	Attend
R403	Critical Design Review	As scheduled.	Approve

R404	Test Readiness Review	As scheduled.	Approve

3.4.5 Option 3 (Task V) Deliverables

Item #	Item Description - Data	Due Date	ONR Action
D501	Monthly Technical and Financial Status Reports	20th working day of every month	Review
D502	Transition Plan	3 months ARO	Review
D503	Semi-Annual Reports	Every 6 months ARO	Review
D504	Cost benefit analysis detailing a trade space analysis for design and implementation of the GOAL	With Final Report	Review
D505	Interface Control Document for ACCUS System	With Final Report	Review
D506	Updated Global open architecture layer software (i.e., source code)	With Final Report	Review

Item #	Item Description – Meetings & Reviews	Due Date	ONR Action
R501	Bi-Weekly program management telecons	As agreed bi-weekly	Attend
R502	Bi-Weekly Technical telecons	As agreed bi-weekly	Attend

3.5 Tentative Milestone Schedules

3.5.1 Task I Milestone Schedule (18 months)

- Task Award 30 Sep 2012
- Kickoff Meeting 17 Oct 2012
- System Requirements Review 17 Nov 2012
- Quarterly Program Review 31 Dec 2012, then every 90 days
- Preliminary Design Review 17 Feb 2013
- Critical Design Review 31 Jul 2013
- Test Readiness Review 30 Dec 2013
- Flight Readiness Review 06 Mar 2014
- Flight Event 07 Mar 2014
- Quick Look Report 17 Mar 2014
- Final Report 31 Mar 2014

3.5.2 Task II Milestone Schedule (11 months)

- Task Award 03 Apr 2014
- Kickoff Meeting 15 Apr 2014
- Quarterly Program Review 01 Jul 2014, then every 90 days
- Critical Design Review 30 Aug 2014
- Test Readiness Review 03 Jan 2015
- Flight Readiness Review 01 Feb 2015
- Flight Event 02 Feb 2015

- Quick Look Report 10 Feb 2015
- Final Report 31 Feb 2015

3.5.3 Task III Milestone Schedule (13 months)

- Task Award 02 Mar 2015
- Kickoff Meeting 15 Mar 2015
- Quarterly Program Review 31 May 2015, then every 90 days
- Critical Design Review 02 Aug 2015
- Test Readiness Review 02 Jan 2016
- Flight Readiness Review 04 Mar 2016
- Flight Event 05 Mar 2016
- Quick Look Report 15 Mar 2016
- Final Report 29 Mar 2016

3.5.4 Task IV Milestone Schedule (11 months)

- Task Award 01 Apr 2016
- Kickoff Meeting 15 Apr 2016
- Quarterly Program Review 02 Jul 2016, then every 90 days
- Critical Design Review 05 Sep 2016
- Test Readiness Review 03 Dec 2016
- Flight Readiness Review 01 Feb 2017
- Flight Event 02 Feb 2017
- Quick Look Report 15 Feb 2017
- Final Report 31 Feb 2017

3.5.5 Task V Milestone Schedule (12 months)

- Task Award 03 Dec 2016
- Kickoff Meeting 17 Dec 2016
- Quarterly Program Review 05 Mar 2017, then every 90 days
- Technology Transition Plan 30 Aug 2017
- Lessons Learned 31 Sep 2017
- Technical Data Package 29 Oct 2017
- Final Report 29 Nov 2017